E
378.748
OS1904.4

REFERENCE

LIBRARY OF THE UNIVERSITY OF PENNSYLVANIA

E378.748
POS1904.4

GIFT OF
Univ.

Myers & Pratt '04
Suction Producer
64

THESIS

TEST OF GAS ENGINE

AND

PRODUCER PLANT.

E.B. MYERS.
H.D. PRATT

E 378.748
POS 1904.4

✓

UNIVERSITY
of
PENNSYLVANIA
LIBRARIES

20 May '48. Sec. of Univ. M. Edward Brittain

The following tests were made on a 13" x 22^1/2" Otto Gas Engine at 1214 Spring Garden Street:-

The gas used in this engine is generated by a No.1 Otto Suction Gas Producer.

At the request of the manufacturers a detailed description of the Producer is not given.

The Plant consists in the main of the producer, scrubber, gas receiver and the gas engine.

The Producer consists of a cylindrical stove lined with fire brick and filled with anthracite coal, with a grate below and a coal hopper and cover above.

The admission stroke of the engine draws air through the producer. This air circulates above a water seal and, as the fire is next this seal, takes up a certain amount of moisture. This mixture is drawn through a pipe external to the producer and is then admitted below the grate and sucked up through the hot coal in the hopper. It is here that the gas is really produced. The gas is then passed through a water seal in the bottom of the scrubber and is here cleansed of

all its impurities by coming in contact with coke and other porous material and running water. The gas then continues, under the suction of the admission stroke, and is lead through a 6" pipe into a wrought iron receiver 4' long by 2' in diameter. Here the gas deposits all the moisture accumulated in the scrubber and from here enters the mixing chamber from whence it enters the cylinder of the engine.

The producer fire is renewed every week so that the coal and wood were weighed out on Saturday afternoon and put in the producer to be ready on Monday morning.

The producer was stoked twice daily, once in the morning and once at noon. The average amount put in to start the producer was 600#, about 165# every noon and about 200# every morning.

The coal used was weighed out in buckets. The ashes came out partly wet, the wet part being spread out and dried before weighing. The total weight of ashes for one week was found and a fraction of this equal to $\frac{31.5}{57.5}$ was taken as the amount for three days. The

fraction represents the ratio of the length of the test to the total time the engine is run in one week.

The B.H.P. was obtained by means of a band Prony Brake. This brake worked on a broad pulley bolted To ~~on~~ the fly wheel of the engine. The load was obtained by hanging known weights on the arm of the brake. In this test cards were taken every five minutes for 20 minutes together with all the other readings taken in three day run, except the quantity of water used in the scrubber.

The engine run by the producer plant is design #9 Otto Engine, designed for 48 horse power with producer gas and 60 horse power with city gas, made by The Otto Gas Engine Works, Philadelphia, Pa.

The engine is of the four cycle type governed by the "Hit and Miss" type governor.

The engine frame, cylinder, water jacket and

cylinder head are all cast in separate pieces, and thus repairs may be easily and quickly made.

In this engine all the valves are poppet valves seated in casings separate from the engine head, but secured by means of bolts and nuts.

The exhaust gases are led direct to a wrought iron muffler and then to a second muffler in the cellar. From here the exhaust gas is admitted to the base of the chimney.

The engine is water jacketed throughout. This cooling water is led to the engine through a 1^{1}/2" pipe. To keep the exhaust valve cool, a separate outlet is provided from it to insure free circulation around the casing.

In case the producer should break down, the engine is fitted so that it can continue running on city gas without loss of time.

It this plant city gas is used to start the engine but this is not necessary. It can be started on producer gas, but it takes more time to do this.

The average time of starting the engine, including hand compression of the first charge, is about two minutes.

The amount of city gas used in starting was from 40 to 80 cu.ft. depending on the quality of the producer gas. The gas becomes bettwr after one or two days of running, from the time the fire is first made up.

The following determinations were made:-

Total coal consumption per I.H.P. hour, the I.H.P. under ordinary load of running the shop, heat carried away by jacket water, amount of water used in producer and scrubber per I.H.P., and the mechanical efficiency of the engine. All but the last were determined by a test of three whole working days, starting at 7 A.M., stopping from 12 to 12.30 P.M. and shutting down at 6 P.M. The following observations were taken every fifteen minutes for the whole three days:-

(1) Indicator cards.

(2) Revolutions.

(3) Explosions.

(4) Temperature of water to jacket.

(5) Temperature of water leaving jacket (cylinder).

(6) Temperature of water leaving jacket (exhaust valve).

(7) Quantity of water passed through scrubber & producer.

(8) Quantity of water passed through cylinder jacket.

(9) Quantity of water passed through exhaust jacket.

The indicator cards were taken from a Thomson indicator with a small size piston and a 100# spring. The indicator was screwed to a tap at the end of the cylinder and run by an Apgar reducing rig. The Apgar rig was held between the piston and crank by a wrought iron brace, which was held by the lock nuts on the main bearing cap.

A calibration of the indicator spring gave 199.2# instead of 200# as the scale of the spring using $^{1}/2$ size piston. Revolutions were counted with a continuous revolution counter worked by a pin in the end of the cam shaft. The actual revolutions were therefore twice the readings of the revolution counter.

Explosions were counted by means of a continuous revolution counter, attached to the arm operating the gas admission valve. The readings of this counter corresponded therefore to the actual number of explosions.

The temperature of the ~~feed~~ Entering water was obtained by introducing a thermometer well into the pipe line, about four feet from where the water entered the jacket.

The temperature of the water leaving jacket was found from a thermometer hung in the waste pipe. The temperature of the water leaving the jacket around the exhaust valve was found in the same way. In working up results the mean value of the various temperatures was taken by averaging them up for each day separately. Fahrenheit thermometers were used.

The quantity of water used by the producer and scrubber was measured by an Empire Meter, made by Standard Meter Company, New York, reading gallons, introduced in the pipe line leading to the producer. A calibration of this meter gave .980 as a correction factor.

The water through the jacket was measured by ~~the~~ a Schaeffer & Budenburg meter, reading cubic feet, placed in the exhaust pipe leading from the cylinder jacket. A calibration of this meter gave .988 as correction factor. Both this meter and the one above had a by-pass and valve in order to cut them out if necessary.

The water passing through the jacket around the exhaust valve, was measured directly with a tank and scales; it was carried out of the engine room into the shop by a $^{3}/8$" pipe in which a thermometer was introduced about 2 feet from the exhaust jacket.

INDICATED HORSE POWER.

The mean I.H.P. for each day was calculated as follows:- The engine when under the load, due to the shop, would make from two to four explosions; the governor would then cut off the gas for several revolutions and another series of explosions would occur. In taking the indicator cards, a whole series was taken on each card. The first explosion always gave a card smaller than the following ones. This card is called the "low" one, the others "high". The high cards, in each series, were almost identical in area. To get the mean area, the ratio of high cards to low was found for the whole day's run. Suppose this to be 2:1. The mean "high" area was then given a value of 2 and the "low" a value of 1; they were then added and divided by 3. The M.E.P. was found by dividing this resultant area by 3.45", which was the uniform length of the cards, and multiplying by 199.2, the scale of the indicator spring found by calibration. The engine constant

The N in $\left(I.H.P = \frac{P.L.A.N.}{33000.} \right)$ was taken as explosions

UNIVERSITY
of
PENNSYLVANIA
LIBRARY

per minute.

Example:- Mean high card area, for first day's run = 1.17 square inches. Mean low area = .857 square inches. Ratio = 2.23:1. Resultant card = $\frac{2.23 \times 1.17 + .857}{3.23}$ = 1.08 square inches. Length = 3.45"

Area of 13" piston = 132.7.□" Explosion per minute = 53.1

$$M.E.P. = \frac{1.08 \times 199.2}{3.45} = 62.3^{\#}$$

$$I.H.P. = \frac{62.3 \times 22.5 \times 132.7 \times 53.1}{12 \times 33000} = .00755 \times 62.3 \times 53.1$$

$$= 25.8$$

BRAKE HORSE POWER.

The brake horse power was calculated as follows:-

Brake arm = 3.06 feet. Brake constant = $\frac{2\pi \times 3.06}{33000.}$ = .000582

B.H.P. = .000582 x load on brake x revolutions per minute.

Example:- Load = 290#. R.P.M. = 216.

B.H.P. = .000582 x 290 x 216 = 36.4

The heat carried off by the jacket water was found as follows:- (1) From cylinder jacket (first day's run) Mean feed temperature = 57.2°F. Mean temperature water leaving jacket = 99.8°. B.T.U. carried off per pound 42.8 B.T.U. Total weight of water in day's run = 13900#.

Total heat = 13900 x 42.8 B.T.U. or $\frac{13900 \times 42.8 \times 778}{33000 \times 600} = 23.3$ H.P. ~~per min~~

(2) Exhaust jacket. Mean feed = 57.2°. Mean temperature leaving = 109.5°. B.T.U. per pound = 52.5. Total water per minute = 5.44#.

Horse power carried off $\frac{5.44 \times 52.5 \times 778}{33000} = 6.73$

Total horse power per min. carried off

$$\begin{array}{r} 23.3 \\ 6.73 \\ \hline 30.03 \end{array}$$

~~Per minute~~, I.H.P. = 25.8

JACKET HORSE POWER. (BRAKE TEST.)

Example:- (1) Cylinder Jacket

Temperature jacket water (mean) = 118°F.

Temperature feed water (mean) = 61°

$$\begin{array}{r} Q_2 = 86. \\ Q_1 = 29.1 \\ \hline 56.9 \text{ BTU.} \end{array}$$

Amount water = 13.2 cubic feet in 31 minutes.

Horse power = $\frac{13.2 \times 62.5 \times 56.9 \times 778}{31 \times 33000} = 35.7$ ~~per min~~

EXHAUST JACKET.

Temperature water leaving jacket = 124°

Temperature water, feed = 61°

$$\begin{array}{r} Q_2 = 92.1 \\ Q_1 = 29.1 \\ \hline 63.0 \text{ BTU} \end{array}$$

Amount water = ~~415#~~ 314# in 31 minutes.

Horse power = $\frac{314 \times 63 \times 778}{31 \times 33000.} = 15$ ~~per min~~.

Total = 15 + 35.7 = 50.7 horse power. ~~per minute~~.

I.H.P. = 38 .0

FINAL RESULTS.

Coal per hour of running = 37.4#

Mean I.H.P. (including 31.5 hours at 25.03 I.H.P. and I.H.P's. of 38 and 52.2 for brake test runs of 31 minutes and 11 minutes respec~~tfully~~tively) = 25.3

Coal per I.H.P. hour $= \frac{37.4}{25.3} = 1.48\#$

Coal for starting = 574# or $\frac{574.}{57.5}$ per hour of running =

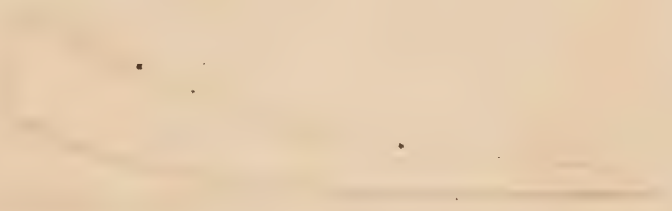
10# per hour.

Coal per I.H.P. hour $= \frac{47.4}{25.3} = 1.88\#$

SAMPLE CARD

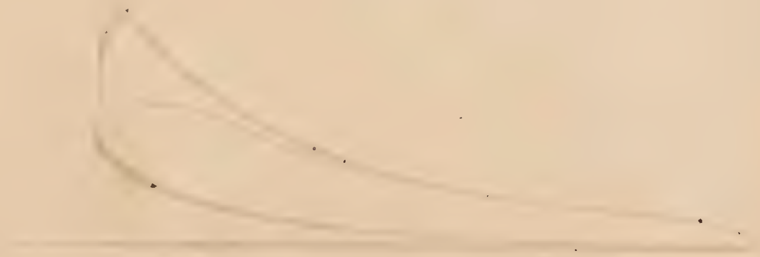
7.45 AM 4/25/04.

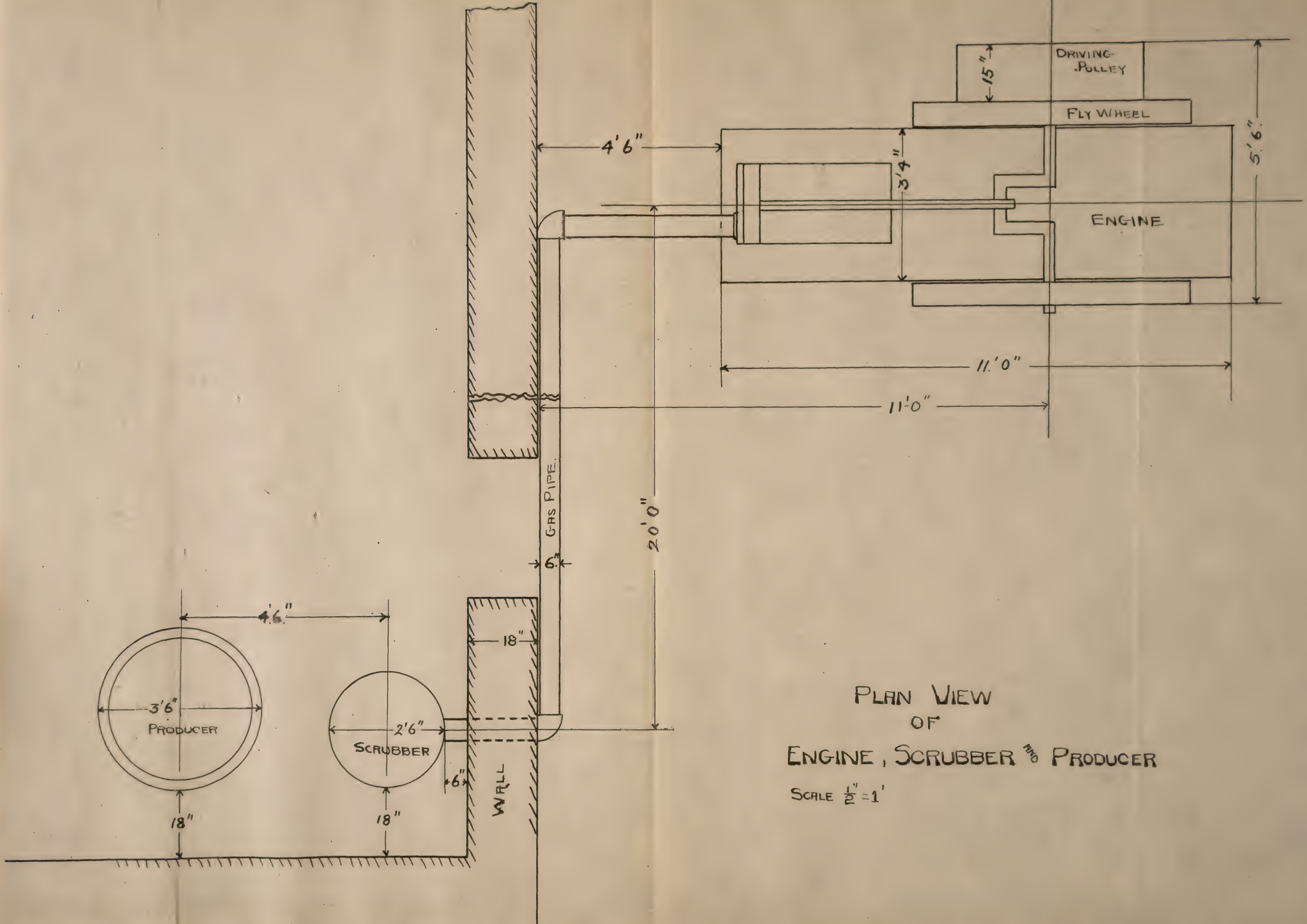
PRODUCER GAS POOR
AT TIME OF STARTING.



SAMPLE CARD

NORMAL CARD UNDER
SHOP LOAD.




DRIVING PULLEY
15"
FLY WHEEL
5'6"
4'6"
3'4"
ENGINE
11'0"
11'0"
GAS PIPE
6"
20'0"
4'6"
18"
3'6"
PRODUCER
2'6"
SCRUBBER
6"
WALL
18"
18"

PLAN VIEW
OF
ENGINE, SCRUBBER AND PRODUCER

SCALE $\frac{1}{2}''=1'$

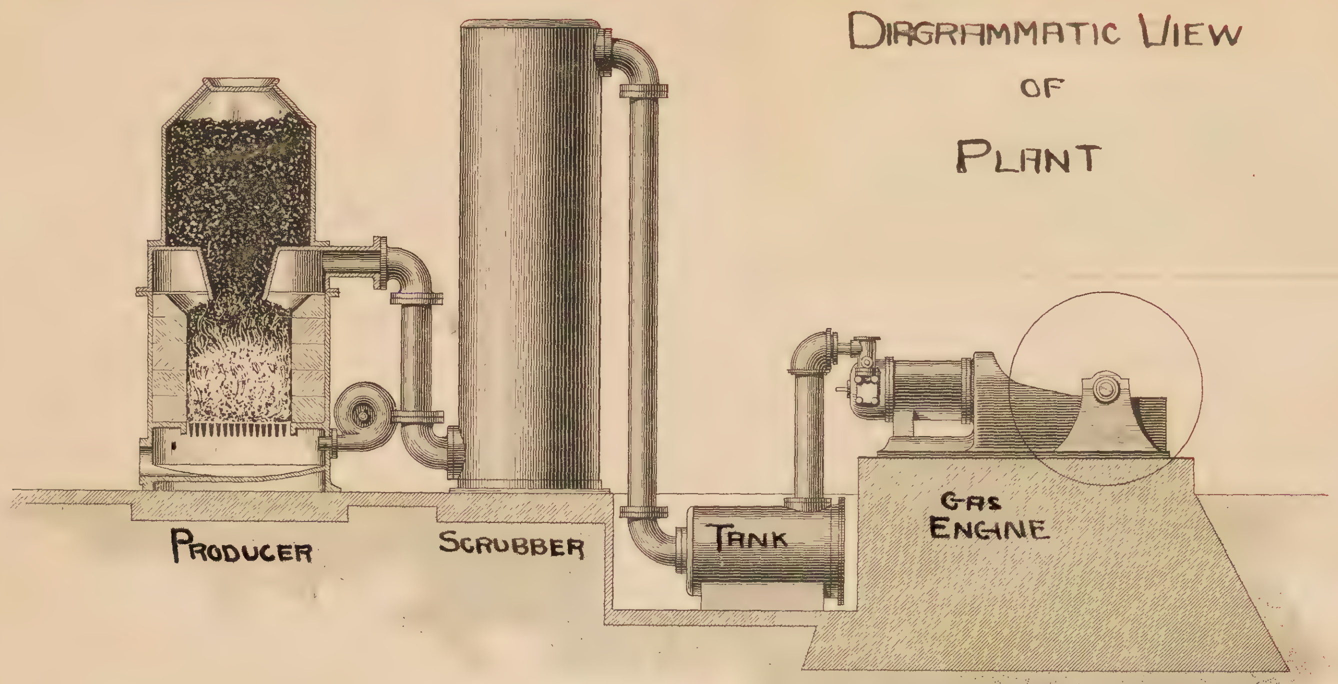
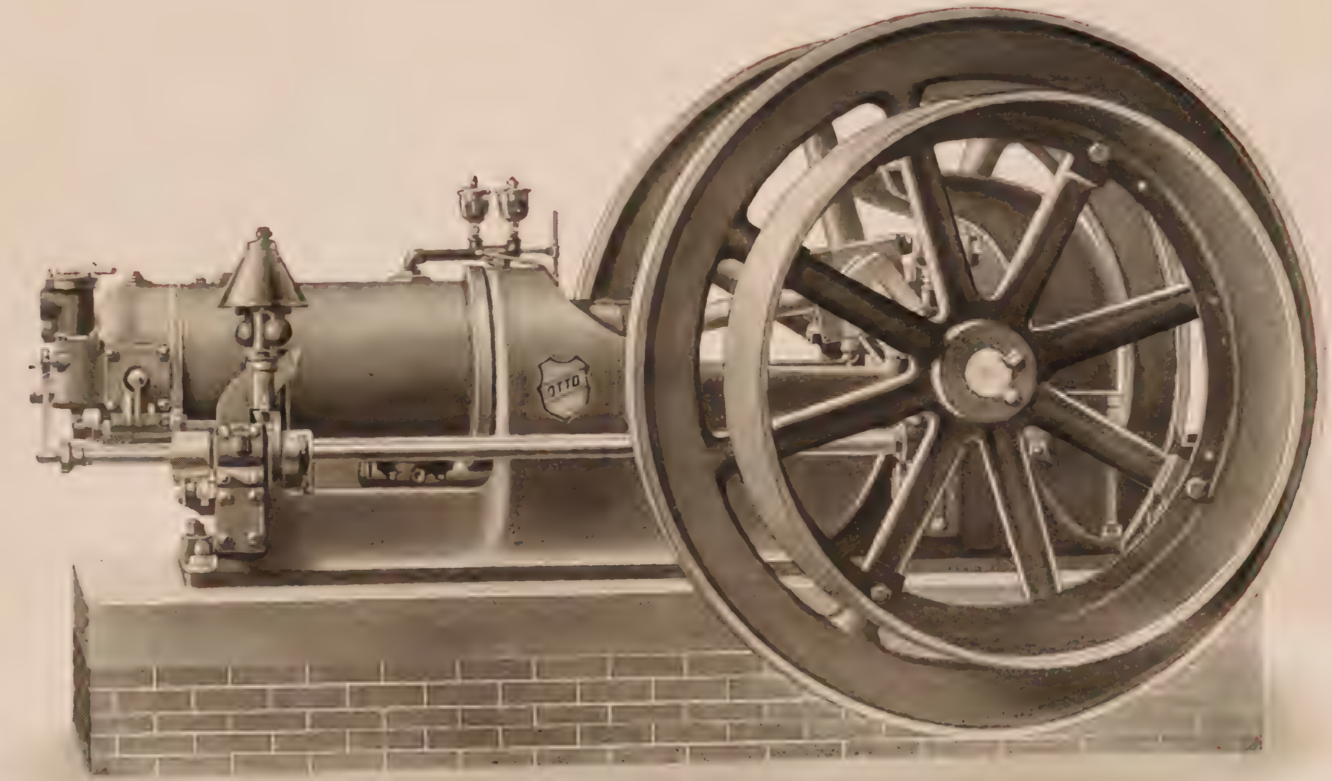

DIAGRAMMATIC VIEW
OF
PLANT
PRODUCER
SCRUBBER
TANK
GAS
ENGINE

Fig. 1. Under Fifty Horse Power


OTTO

INDICATOR SPRING CALIBRATION

PRESSURES ASCENDING

ACTUAL POUNDS	IND'C POUNDS	ACT. IND'C
10	10	1.00
20	20	1.00
30	30	1.00
40	40	1.00
50	50	1.00
60	60	1.00
70	70	1.00
80	80	1.00

MEAN = 1.00

PRESSURES DESCENDING

ACTUAL POUNDS	IND'C POUNDS	ACTUAL IND'C
10	10	1.00
20	20	1.00
30	31	.969
40	41	.976
50	50	.980
60	60	1.00
70	70	1.00
80	79	1.01

MEAN = .9919

MEAN [UP AND DOWN] $= \frac{1.00 + .9919}{2} = .99597$

∴ SCALE FOR 100# SPRING WITH ½ SIZE PISTON.

$= 200^{\#} \times .99597 = \underline{199.19^{\#}\text{D}''}$

Conclusions.

The Suction Producer Plant as tested in this Thesis was very efficient and required very little attention. One man had the plant under control and was busy only a few hours per day.

The Outfit takes up very little space and is compact in every detail.

The ashes are very few and the Producer is stoked but twice daily.

In the week, in which we made the tests, the Engine ran steadily ten and one half hours per day, without mishap or slow-down of any sort.

The coal consumption per running hour per I.H.P. was found to be 1.48#.

The coal consumption per I.H.P. hour taking into account amount used in starting = 1.88#.

SAMPLE
BRAKE TEST LOG.

TIME	EXP	TIME	R.P.M.	TIME	CYL METER CU. FT	TIME	JACKET WT. #	$^*T_J$	$^*T_{J_1}$	$^*T_{FEED}$	BRAKE LOAD
9.19	8804	9.19	4564	920	463.8	921	197	106	118	61	BRAKE CONSTANT LOAD = 82#.
9.26	9201	9.26	5329	928	467.3	9.28	229	107	118	60	
932	9516	9.32	5985	933	468.5	9.32	252	107	116	60	
9.37	9779	9.37	6532	9.38	470.5	9.38	290	96	112	60	
945	10185	9.45	7403	9.46	473.8	9.46	340	96	109	61	

SAMPLE
3-DAY RUN TEST LOG.

TIME	EXP'L	R.P.M	TIME	CYL METER CU. FT	TIME	SCRUB METER GALL'S	TIME	JACKET WATER IN #S	$^*T_J$	$^*T_{J_1}$	$^*T_{FEED}$
7.30	6618	8626	731	751.0	731	4555	730	264	82	97	56
7.45	7584	10214	745	756.5	7.45	4609	7.46	366	88	102	58.
"	"	"	"	"	"	"	"	"	"	"	"

EVERY 15 MINUTES FROM 7.00 A.M. – 6.00 P.M. SHUT DOWN FROM 12.00 NOON 12.30 P.M.

6.00 P.M.	8414	4400	559	973.5	5.59	6567	6.00	380	103	113	58.

$^*T_J$ = TEMP. IN DEG. F. OF WATER LEAVING CYL. JACKET

T_{J_1} = " " " " " " " EXH. VALVE JACKET.

T_{FEED} = " " " " " " " ENTERING JACKETS.

RESULTS

3 DAY TEST

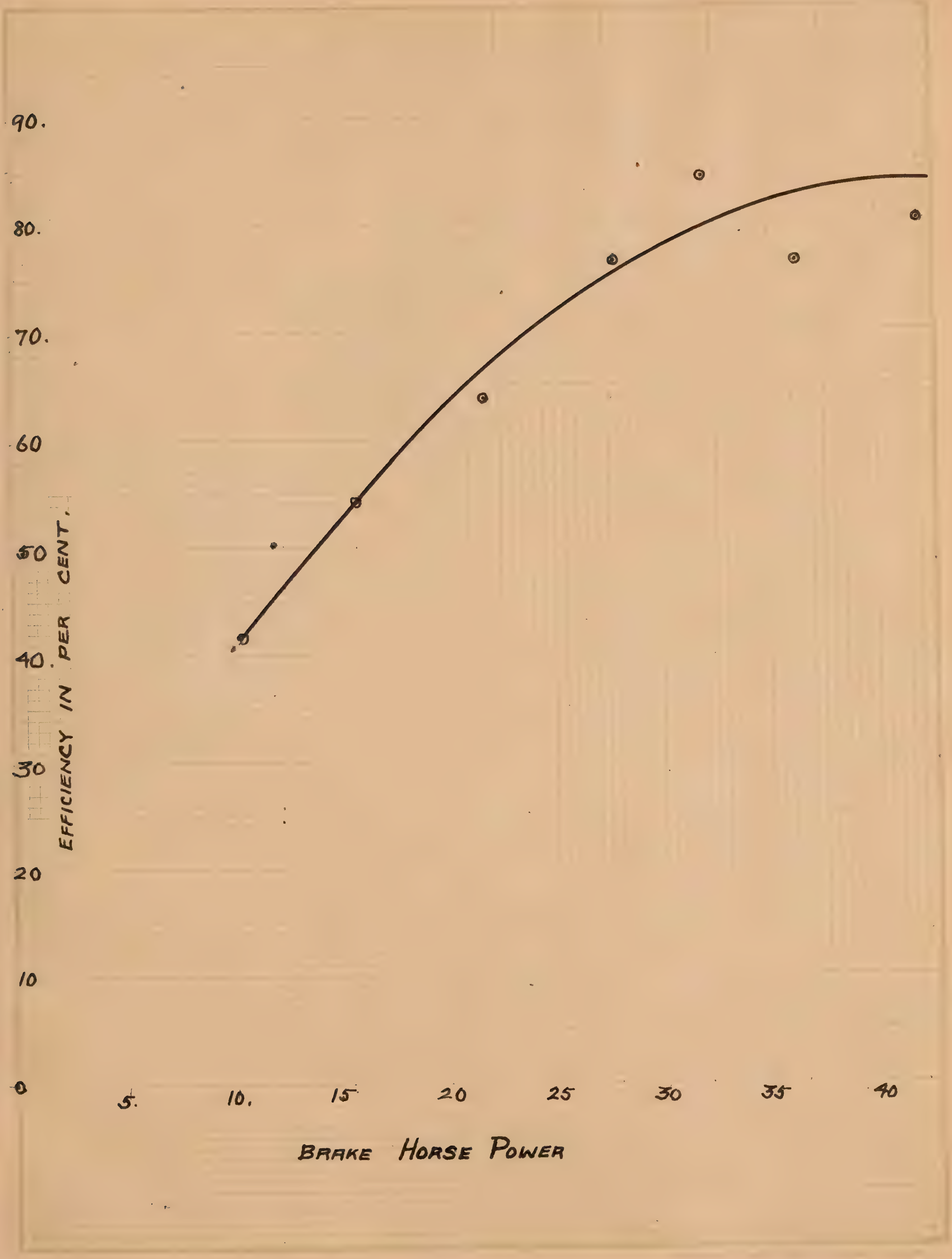
FIRST DAY . MEAN RESULTS

R.P.M	EXP'L	I.H.P	SCRUB WATER GAL'S PER I.H.P. HR	JACKET WATER GAL'S PER I.H.P. HR	JACKET H.P	T_o	T_J'	T_J
222	54.8	25.8	8.04	7.91	30.1	57.2	109.5	99.8
SECOND DAY MEAN RESULTS								
219	46.1	23.1	9.06	8.88	28.6	58.5	111	98.2
THIRD DAY . MEAN RESULTS								
219	49.2	26.2	6.76	7.82	29.1	58.3	109.5	99.5

Brake Test Condition

The shop is run by this engine by means of a very tight Belt. This belt is connected to a heavy Pulley on the main shaft of the shop. This pulley is connected to the shaft by means of a friction clutch. Now during the Brake tests made, the shop load was thrown off by means of this friction clutch but the heavy pulley and tight belt still remained on the line.

A considerable amount of power is taken up in driving this mechanism, so the Mechanical Efficiencies at the low loads are proportionally low because of this power absorbed.


90.
80.
70.
60
50
40.
30
20
10
0
5.
10.
15
20
25
30
35
40
EFFICIENCY IN PER CENT.
BRAKE HORSE POWER

This curve of Efficiencies was obtained by plotting Mechanical Efficiencies in Percent as ordinates with B.H.P. as abscissas.

AVERAGE RESULTS
OF

CALIBRATION OF CYLINDER METER.

TIME	METER READINGS. CU. FT.	SCALES READINGS POUNDS
12.01	36.35	245.
12.26	43.80	702

METER CU.Ft = 7.45   ACTUAL = $\frac{457}{62.5}$ = 7.31

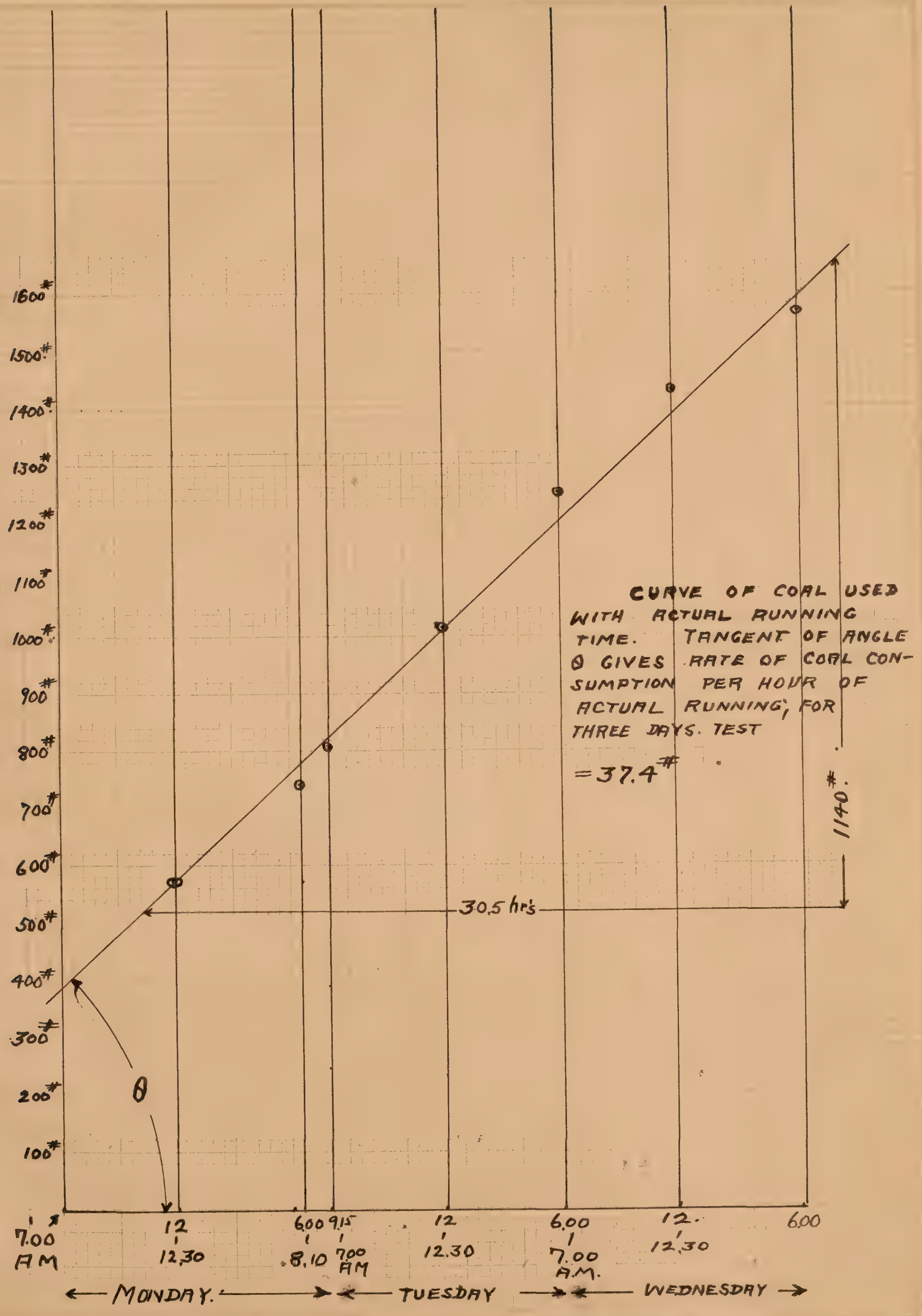
Correction factor = $\frac{731}{7.45}$ = .980 at 1100# per hour. Rate actually used = 1000# per hour.

CALIBRATION OF SCRUBBER METER.

TIME	METER READINGS. GALS.	SCALES READINGS POUNDS
10.39	36.1	124
10.52	100.1	650

METER POUNDS = 533#   ACTUAL LBS = 526

Correction factor = $\frac{526}{533}$ = .988 at rate used = 210 gals per hour.



CURVE OF COAL USED WITH ACTUAL RUNNING TIME. TANGENT OF ANGLE θ GIVES RATE OF COAL CONSUMPTION PER HOUR OF ACTUAL RUNNING, FOR THREE DAYS. TEST =37.4#

The Curve of Coal Consumption was obtained by plotting total coal consumption with actual running time.

These points were plotted as above and a straight line drawn through them.

Calling, θ, the angle made by this line with the Horizontal, the coal per running hour is equal to the tangent Angle θ.

This takes no acc

The coal per HP Hour, taking into account the coal used in starting, was obtained by adding ~~to~~ [[the amount of coal used in starting divided by running time of one week]] to the amount of coal per running hour.

3 1198 03070 5615
N/1198/03070/5615X

E378.748 POS1904.4

FOR REFERENCE

NOT TO BE TAKEN FROM THIS ROOM

CAT. NO. 1935 LIBRARY BUREAU

3 1198 03070 5615
N/1198/03070/5615X

STO